M'Kendrick - To what end?

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REMARKS MADE AT THE CLOSE OF THE THOMSON LECTURES FOR 1894-95, IN THE FREE CHURCH COLLEGE, ABERDEEN, ON

THE PHENOMENA OF LIFE.

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In drawing this course of lectures to a close, we may ask ourselves the question—What general notions regarding the nature of living action may be formed from a careful consideration of the facts marshalled along the four lines of evidence brought under review, namely, the histological, chemical, physical, and experimental? My object has been to illustrate the progress of physiology along these four lines of research, so as, if possible, to give you a view of the aims and problems, the difficulties and the successes, of physiological science.

In the first place, we have seen that the microscope of the present day, which bears the same relation to the microscope of fifty years ago as a modern astronomical telescope does to that used by Galileo, aided by special methods of preparing the tissues for examination, has revealed details of structure in certain kinds of living matter that have hitherto been regarded as structureless, and, in particular, has shown remarkable phenomena in the nuclei of cells during the reproductive process. Particles of living matter, the diameters of which are expressed in thousandths of an inch, are the arena of movements of a definite character, and apparently for a definite purpose; and there is a strong probability, to say the least of it, that these movements afford a physical

basis on which may be constructed a theory of hereditary transmission. At the same time, we must admit that the physical possibilities of the microscope, as an instrument of research, have nearly reached their limits, and that we have no right to assume that there may not be movements in living matter which will never be revealed by the microscope ; or, to put the statement in the positive form, it is highly probable that the smallest bit of living matter we can see with the highest powers contains still smaller physiological units. Such units may never be seen, but we are at liberty to postulate their existence when we attempt to explain some of the phenomena of life.

We then found that the chemical investigation of the phenomena of life is attended with peculiar difficulties. The analysis of living matter is impossible, because analysis destroys the condition we wish to investigate, and, consequently, our knowledge of the chemical phenomena in living matter must depend on our knowledge of the chemical constitution of matter that has once lived, and on the chemical behaviour of living matter in certain special conditions. Still we learned enough to satisfy ourselves that the phenomena of vitality are always associated with chemical phenomena, such as the absorption of oxygen and the giving off of carbonic acid and other waste products. Again, however, we found that when living matter is the seat of chemical exchanges the phenomena are always of a molecular character, and occur in conditions that cannot be imitated by the chemist in his laboratory, showing that the vital condition is *sui generis.*

We have also sketched the influence of physical methods of research, showing how it is possible to obtain

information as to vital phenomena that would escape observation by the unaided senses. These methods bring to light the fact that phenomena are not always what they seem to be, and that many changes, fundamental in their character, may escape our unaided senses. Such phenomena are illustrated by the latent period of muscular contraction, the rate of transmission of the nervous impulse, and the facts of animal electricity. Physiology has gained much, and will gain much more, by the rigorous application of physical methods, but the results obtained have hitherto failed to explain the essential phenomena of living matter, and have only made them more difficult of comprehension. The problem of the essential phenomena of a muscular contraction, or of the transmission of the nervous impulse, has not been much advanced by the knowledge we possess of a muscle curve, and of the rate at which a nervous impulse is transmitted. Still less do we understand in what way electrical phenomena are always associated with vital activity.

Lastly, we shortly referred to the experimental method by which physiologists are at present engaged in unravelling the intricacies of the central nervous system, and we saw that a simpler plan of the nervous mechanism is being slowly worked out. Complicated as the central nervous axis, brain and cord, may at present seem to be, there are indications that its arrangements are in reality constructed on a simple plan, by which segment is bound to segment, and each to all the rest. Still this method throws no light on the real nature of nervous action, and does not presume to discuss that question of questions, the relation of nervous activity to consciousness.

Probably one of the impressions made on your minds, as you listened to those lectures, is that

physiological science abounds in striking examples of exquisite adjustments and arrangements for the attainment of certain ends. It is a truism to state that organs and tissues are adapted, by their structure and chemical constitution, for the performance of specific functions, and yet it is a truism that must ever be kept in mind. Each living unit, such as a cell or the structures formed from cells, is, like a living being in the animal or vegetable kingdoms, adapted to its environment, by which I mean the normal conditions of its existence. Modifications of these conditions affect the functional activity of the organ or tissue, and if the organ or tissue is submitted for a sufficient length of time to new conditions, its texture and histological structure are more or less slowly altered. Thus it is that in the study of the development of organs and tissues we are brought face to face with the same problem as meets the naturalist in his attempts to explain the origin of the innumerable plants and animals that form the subjects of his study. How have tissues originated? How have organs originated? How have certain mechanisms been formed so as to be adapted to the wants of the higher grades of animals? Take the simplest tissues as you find these in the body of man. In the animals immediately below him in the scale of existence, you find such tissues similar but not identical, and, as you pass down the scale, you find the points of similarity in structure gradually disappearing until you come to tissues in the lower forms that are unlike those in the higher, although they fulfil the same general functions. Trace in this way the connective and muscular tissues up through the animal kingdom and you find a gradual advance, so that the connective tissue and muscle of a

higher mammal are more highly differentiated structures than those, say, of an amphibian or a fish. There has been an advance along the whole line. Every tissue and organ have shared in this progress. The body of one of the higher animals, say that of man, is not therefore an advance only as regards brain and nervous system, as many suppose, but it is a more complicated machine in every detail of its structure. I do not deny that some of the higher mammals have certain tissues and organs more highly developed than we find them in man (as, for example, the olfactory organ in many animals), but I assert that my statement is generally true. This general advance must be to meet the higher requirements of the higher organisms. What is it that determines these higher requirements? Evidently it is the evolution of higher and higher psychical properties. For a living being to have sensations, perceptions, emotions, volitions, and powers of reason more developed than one lower in the scale, it is necessary to have a more differentiated nervous system, and the degree of development of this part of the body determines the degree of development of all the rest. Or, you may state the case in another way: the highly differentiated nervous tissues of man require for their complete development a correlative advance in all the other tissues. Thus epithelium (especially in the sense organs), nerve fibres, nerve cells, muscular tissue, and even connective tissues in man and the higher mammals are all of a higher order than in many of the lower animals because they have all to do with the upbuilding and the upkeep of a more differentiated brain, associated with which we find higher psychical characters.

Organization therefore is working up to an adequate

manifestation of mind. Mind is the final outcome of those differentiations that have gone on through countless ages in the upbuilding of the kingdoms of living nature, and also in the upbuilding of the highest representative of the highest kingdom, man. Thus we see how the textures and organs of the body are in a sense subservient to the manifestation of mind; and can we doubt that the wonderful progression, the orderly sequence of events in the life history of countless animals, the elaboration of more and more complicated tissues in the higher animals until we reach man, processes that have had for their outcome the appearance of mind, must have been directed by Mind itself? To me any other hypothesis is inconceivable. Observe, it is not progression alone that calls for our attention. It is not merely orderly progression. It is progression along a certain definite line that culminates in the manifestation of mind, and the more we scrutinize physiological phenomena of all kinds, the more it becomes evident that they are subservient to this main end. This can only be accounted for by recognizing thought as underlying, controlling, directing all living phenomena, and thought, I need hardly say, presupposes a Thinker. Any purely physical explanation of thought is to my mind unreasonable, and if, as I have indicated, thought underlies all physical and vital phenomena, and so controls these as to secure as an ultimate phenomenon the manifestation of itself, then I have no difficulty, from the point of view of science, in believing in the existence of a Great Being who is the Source of Energy of this Universe and of all Living Things. This argument advanced from the physiological side has numerous applications.

Let us come back to the question: How far can we

account for the phenomena of life? Have we yet reached that stage in the history of physiological science at which its conclusions may be accepted, and when we may safely apply them to the consideration of certain great questions that form the subject of study in a theological college? This is probably the aspect of the matter that fascinates the attention of theological students. It cannot be expected that you will be profoundly interested in the relation of physiological science to the technical art of medicine, nor even to the position of physiology among the sciences, and I will also acquit you of the utilitarian view that physiology is only a science that teaches a man what to eat and to drink, and how to live in a state of health and vigour. You wish to know what are its first conclusions. What has it to say regarding those problems that have a bearing on the problems of man's being and destiny? How does it deal with those questions in philosophy that form the foundations of ethics and theology? In particular, what has it to say regarding the nature of life?

In the first place, a historical consideration of the subject shows us that opinions regarding the nature of life have passed through various phases, and that these phases have been largely influenced by great discoveries or by the rise of wide-sweeping generalizations in the allied sciences. Thus, at one time, and at a time corresponding with the development of accurate ideas regarding mechanics and the interplay of mechanical forces, a mechanical explanation was offered of many vital phenomena. For example, it was thought that the phenomena of the circulation might be completely explained by the principles of hydraulics, and muscular motion, in the hands of such a philosopher as Borelli, was resolved into a series of problems and theorems based on purely me-

chanical considerations. Again, when the more intimate interchanges of matter that form the subject of chemical research were studied with diligence and success, a school of chemical physiologists arose who thought of life as a series of fermentations, oxidations, reductions, and such like phenomena. To Paracelsus, the first of the chemical physiologists, the emblem of life was a flame, a torch, a combustion, a something in its essence entirely chemical. These mechanical and chemical schools were always in sharp conflict with the vitalists, with such men as Stahl and Whytt and Boerhaave who upheld the view that the essence of life is something immaterial, and that a spirit, an *archeus*, a vital energy, pervades all living matter, endowing it with its properties, and controlling all the physical and chemical operations of which that matter might be the seat. Again, when electrical science took its start, not much more than one hundred years ago, in the physiological experiments of Galvani, electricity became a word that, for a time, was almost synonymous with life, and men thought that "whatever stirs this mortal frame," especially in nervous actions, was but a manifestation of this all-pervading force.

In our own century we have had a striking example of the oscillation of opinion. During the first two or three decades, physiologists were mainly vitalists, although no doubt here and there men were engaged in experimental investigations who were guided by mechanical and chemical conceptions. With the rise of the great generalization of the conservation of energy a new impetus was given to physiological science. If the forces of nature were so related that at no moment could a new force be created or destroyed; if, as was theoretically calculated by Mayer and experimentally demonstrated by Joule, there

was a quantitative relation between any two forces, such as motion and heat; but if no such quantitative relation could be established between the ordinary forces of matter and vital action (especially that form of vital activity we call consciousness), thinkers asked the question: Is there a force in living matter distinct from all the other forces, or, in other words, is there such a thing as vitality or a vital force? Many gave a negative answer. The pendulum swung violently in this direction, and materialistic explanations were everywhere in the air. The brilliant researches of such men as Von Helmholtz, Du Bois Reymond, Ludwig, and Donders, each of whom became the centre of a school of eager disciples, advanced to a wonderful extent our knowledge of physiological processes. The principle of the conservation of energy became the guiding idea, and many hoped that all the phenomena of living matter would be brought under its domain. For a time the conception of a vital force was scouted, and a physiologist, such as John Goodsir, whose philosophic mind never was satisfied with a purely materialistic explanation, was regarded as old-fashioned. There can be no doubt that the rise of the physico-chemical school was an immense gain to science. It stimulated research in all directions, and, in thirty years, greater advances were made in the knowledge of living matter than in the preceding four or five centuries. Then again came a time of reflection, and, as was inevitable, profound questions were asked as to the nature of life and consciousness. Thinkers soon came back to the old problems that often before had baffled the strongest intellects. The psychologists pressed the physiologists for an answer, but no answer came. Some of the greatest physiological thinkers, such men as Von Helm-

holtz, Ludwig, and Bernard, said nothing. Even Von Helmholtz, while he laboured so abundantly in the field between physiology and psychology, has written almost nothing that expresses an opinion on the fundamental question of the nature of consciousness. Du Bois Reymond, while avowing himself a materialist, still takes refuge in the word "*Ignorabimus*," and abandons as hopeless the attempt to give a final answer. On the other hand, it must be noted that the very triumphs of physiological research,—triumphs won under the guiding influence of a materialistic hypothesis,—have led physiologists, during the last ten or twenty years, to take up a position, if not less materialistic, at all events implying more caution and judicious restraint. It has been found that, in every case, a purely mechanical explanation of a vital phenomenon is not a complete explanation of the facts. At one time certain vital phenomena were apparently easily accounted for by the application of the laws of physical and chemical action. Thus the absorption of food stuffs from the alimentary canal took place in conformity with the laws that regulated osmotic action, the interchanges of gases in the lungs were supposed to be due to the varying pressures and tensions of the gases on each side of an animal membrane, and the effusion of lymph from the blood into the tissues was looked upon as a mechanical filtration. It is worthy of notice that a more careful examination has shown that in each of these instances the phenomena cannot as yet be entirely accounted for on purely physical principles. In each case a selective action takes place, certain matters may be passed on unchanged, but the rule is that the materials involved in the process are chosen and modified, and that there is a discrimination wholly unaccounted for on the supposition

that the phenomenon is of a purely physical nature. In no instance are the phenomena the same as those which take place when a dead membrane is used instead of a living one. The living membrane, clothed on each side with living cells, modifies and alters the physical process, and gives special characters to the phenomenon in question. The physiologist, therefore, however desirous he may be to explain these phenomena by the application of physical principles, however firmly he may believe that in their essence the phenomena are physical, is bound to admit that the peculiar condition of matter which we call *vital* not only influences and modifies the physical or chemical process, but gives it special characteristics. Life, vitality, the vital condition, the vital force, call it by what name you please, is still the unknown factor, and the further we press on the more mysterious it seems.

Step by step, therefore, the physiologist has been driven to study, not so much the mechanisms we find in the body, such as those of digestion, respiration, circulation, etc., but living matter itself. He is back again to protoplasm, or living stuff. He finds, as I have pointed out in these lectures, that it is not structureless, but that in it there are indications of structure minute and delicate almost beyond conception; he finds also that this living stuff shows much the same properties throughout the whole range of animated existence—it breathes, and moves, and assimilates, and possibly feels—and he finds that the phenomena manifested by this living stuff are fundamentally the same in kind. Thus the phenomena in a secreting cell, in the contractile substance of a muscular fibre, in the tissue of an electric organ, in a nerve cell of the brain or cord, or in the rods and cones of the retina, are all similar in kind, although

varying in degree, and according to the organ in which the structure is found. He is therefore obliged to think of vital phenomena as in their essence molecular: that is to say, that they are due to the interplay, not of large masses of matter, but of molecules, possibly the same molecules as those of the physicist. From this point of view, in the field of what may be called molecular physiology, the phenomena demand for their explanation the existence of molecules and the interplay of molecular forces just as much as the physical phenomena of heat or light or electricity demand for a rational explanation material particles and the interplay of forces in a hypothetical ether or medium in which they are embedded. Thus the phenomena of life, according to my conception, may be as intimately connected with the primary properties of matter, and possibly with the ether that now plays so large a part in the speculations of physicists, as those of gravitation, or light, or electricity, or elasticity. We now see how far off we are from any adequate explanation of vitality. If it is a physical force it is one the nature of which we have hardly begun to understand. To refer it to the interplay of the physical forces already so far known is an insufficient explanation. A study of what we mean by life soon brings us face to face with profound questions as to the real nature of matter and energy that lie at the basis of all science and philosophy.

The thoughtful physiologist runs no risk therefore of becoming a materialist in the grosser sense of the term. The study of his science amplifies and enlarges his views of matter, but when his analysis is pushed to its extreme limits, he is brought face to face with another order of facts and another order of phenomena. To these we give

the name of spiritual, although we cannot define what we mean by this word any more than we can define what we mean by matter or energy. Here the physiologist must stop, and indeed I may say most physiologists stop long before they reach such speculations in the department Herbert Spencer has termed transcendental physiology.

We now pass into another region of thought, that of metaphysics and theology. With this region I have, in such a course of lectures as this, nothing to do. My duty has been fulfilled when I have brought you to the borderland, and when possibly I have led you to the conviction that there is nothing in physiological science which negatives the existence of something beyond its territory. It is, in my judgment, only a superficial view of science that leads any one to assert, as Haeckel does in his last little book on "Monism," that all the phenomena of the universe—mental as well as physical—can be explained as conditions of matter and energy. That may be the outcome in the far-off future, but we may safely assert that our present knowledge does not warrant such a statement, *unless you give to the term energy a much wider meaning than is usually applied to it by physicists.* Whilst, therefore, the attitude of every thinker towards these questions should be one of cautious reserve, and whilst we rest confident in the belief that no speculations on life and death and immortality and God that crush the highest aspirations of the human soul can be truly philosophical, we should beware of hampering the progress of scientific research. Science must be true to her methods and to her canons of criticism. She must work on irrespective of consequences. She must have freedom; and even when we bring her conclusions to the bar and find that they

cannot be justified if they seem to be in conflict with other philosophical conceptions that rest on a sure foundation, such as those of God and Duty and Responsibility, we must not check her course. Theologians need not be afraid of science. They may rest assured that science is a revelation of God, and that sometime or other the views of theologians, which, in their turn, can only be partial and not final, and the views of men of science who deal with the physical universe, will meet at a common point. A monistic theory of the universe will by and by be possible, but not now. What we have to dread are premature generalizations, either on the one side or the other; attempts to establish harmonies where evidently no adjustment is at present possible, and declarations to the unlearned multitude of antagonisms that do not really exist. My last word to you, students of Theology, is the expression of my firm conviction that there is nothing in the doctrines of physiological science inconsistent with the teachings of the Great Founder of Christianity, who, when He discussed some of the mysteries of human existence, brought men back to God by the lessons of the lily of the field and the fowls of the air.

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